

AWARD NUMBER: W81XWH-15-1-0342

TITLE: Toward Personalized Pressure Ulcer Care Planning: Development of a Bioinformatics System for Individualized Prioritization of Clinical Practice Guideline

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REPORT DATE: October 2016

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;
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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE October 2016		2. REPORT TYPE Annual		3. DATES COVERED 30 Sep 2015 - 29 Sep 2016	
4. TITLE AND SUBTITLE Toward Personalized Pressure Ulcer Care Planning: Development of a Bioinformatics System for Individualized Prioritization of Clinical Practice Guideline				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER W81XWH-15-1-0342	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Katherine Bogie E-Mail: kmb3@case.edu				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Cleveland VA Medical Research & Education Foundation, 10701 East Boulevard Cleveland OH 44106-1702				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick, Maryland 21702-5012				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT Over 200 risk factors for pressure ulcer and deep tissue injury (PU/DTI) development have been reported spanning multiple domains. Veterans with chronic spinal cord injury (SCI) have incidence rates as high as 62-80% and 34% will require at least three hospitalizations. PU/DTI may lead to other serious medical complications, such as osteomyelitis, sepsis and even death. Clinical practice guidelines (CPGs) aid clinicians in primary PU/DTI prevention through evidence based practice and expert opinion. However, there are many factors to consider and limited guidance on how to prioritize for individuals. Correction of all PU/DTI risk factors can be both overwhelming and impractical to implement in clinical practice. The relative importance of risk factors has not yet been investigated, limiting care planning and prioritization of interventions. The need to develop effective clinical tools to prioritize the multiple recommendations of CPG has been identified by experts in the field. We will use bioinformatics to enable data extraction, storage, and analysis to support clinical decision support and user-interface development for complex clinical challenges. Our central hypothesis is that the individual's risk factor profile can provide the basis for adaptive personalized PU prevention care planning based on CPG prioritization. The overall objective is to provide weighted systemic insight to PU risk in persons with SCI to support personalized care plans for primary and secondary PU prevention. The SCIPUD+ Resource will be developed using data sets extracted from VINCI together with cross-sectional study of tissue health profiles and validated using an observation cohort study.					
15. SUBJECT TERMS Spinal cord injury, pressure ulcer prevention, clinical practice guidelines, bioinformatics, personalized healthcare					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU Unclassified	18. NUMBER OF PAGES 11	19a. NAME OF RESPONSIBLE PERSON USAMRMC
a. REPORT U Unclassified	b. ABSTRACT U Unclassified	c. THIS PAGE U Unclassified			19b. TELEPHONE NUMBER (include area code)

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1. INTRODUCTION

Over 200 risk factors for pressure ulcer and deep tissue injury (PU/DTI) development have been reported spanning multiple domains. Veterans with chronic spinal cord injury (SCI) have incidence rates as high as 62-80% and 34% will require at least three hospitalizations. PU/DTI may lead to other serious medical complications, such as osteomyelitis, sepsis and even death. Clinical practice guidelines (CPGs) aid clinicians in primary PU/DTI prevention through evidence based practice and expert opinion. However, there are many factors to consider and limited guidance on how to prioritize for individuals. Correction of all PU/DTI risk factors can be both overwhelming and impractical to implement in clinical practice. The relative importance of risk factors has not yet been investigated, limiting care planning and prioritization of interventions. The need to develop effective clinical tools to prioritize the multiple recommendations of CPG has been identified by experts in the field. We will use bioinformatics to enable data extraction, storage, and analysis to support clinical decision support and user-interface development for complex clinical challenges. Our central hypothesis is that the individual's risk factor profile can provide the basis for adaptive personalized PU prevention care planning based on CPG prioritization. The overall objective is to provide weighted systemic insight to PU risk in persons with SCI to support personalized care plans for primary and secondary PU prevention. The SCIPUD+ Resource will be developed using data sets extracted from VINCI together with cross-sectional study of tissue health profiles and validated using an observation cohort study.

2. KEYWORDS

Spinal cord injury, pressure ulcer prevention, clinical practice guidelines, bioinformatics, personalized healthcare

3. ACCOMPLISHMENTS

Major Project Goals

Task 1: Creation of the SCIPUD+ environmental, social and clinical domain database:

Activity dates: months 1-15

Percentage completion: 12%

Task 2: Creation of the SCIPUD+ tissue health domain database:

Activity dates: months 1-30

Percentage completion: 15%

Task 3: Development and validation of the multi-domain SCIPUD+ structural model:

Activity dates: months 6-20

Percentage completion: 10%

Task 4: Observational study of validated SCIPUD+ care plans

Activity dates: months 15-36

Percentage completion: Not yet started

Accomplishment under these goals

Task 1: Creation of the SCIPUD+ environmental, social and clinical domain database:

Activity dates: months 1-15

1) Major activities

a) Obtain approval for access to VINCI data

Completed 01/15/16

Two new study team personnel have been added (Dr. Junheng Ma, JC Seton). DART approvals have been obtained for them to access VINCI data *Completed 06/22/16*

b) Initiate NLP protocol for development of SCIPUDO (SCI PU/DTI Ontology)

SCIPUDO ontology dictionary development was discussed at our kickoff meeting in March 2016. Dr Sun gave the clinicians on the team a brief background on natural language programming and the need to convert text in to data for analysis. *In progress*

c) Define Physio-MIMI based SCIPUD+ Resource database structure

The SCIPUD+ Resource database structure has been developed based on the variables of interest to be extracted from VINCI and collected during tissue health assessments. Once data is extracted from VINCI in a clean and fully deidentified format it will be imported to the SCIPUD+ Resource database. *In progress*

d) Collate and check validated extracted data using our standard deidentified data forms

The study will be extracting VINCI data using ICD-9-CM codes for paraplegia and tetraplegia with a secondary filter using an SCI-specific Stop Code. We have identified these codes and will use them in our initial data extraction query. The search timeframe will be pre-conversion date (Sept 2010 – Sept 2105) because ICD-10 codes do not currently provide accurate delineation of SCI factors. *In progress*

2) Specific objectives

A comprehensive model will be used to relate the primary outcome of interest (PU/DTI development) with covariates including environmental, social, clinical, personal and tissue health profiles and possible interactions among some of these covariates. The SCIPUD+ Resource will be developed using a retrospective chart review of 5,000 encounters selected from more than 40,000 encounters recorded in the VHA including all those with ICD-9-CM codes of 344.00 and 344.1 during the 5 year period prior to start of the study. PU/DTI risk factor data to be collected at multiple retrospective time points will include modifiable and unmodifiable factors identified in cross-sectional and observational studies. Multi-scale data extraction will include numerical, categorical and text data mining. A Spinal Cord Injury Pressure Ulcer and Deep tissue injury ontology, SCIPUDO, will be developed to ensure robust and extensive information extraction from the free text clinical note.

3) Significant Results

Nothing to report

4) Other Achievements

Nothing to report

Task 2: Creation of the SCIPUD+ tissue health domain database:

Activity dates: months 1-30

1) Major activities

a) Obtain local IRB and DoD Human Research Protection Office (HRPO) approval

Completed 02/01/16

b) Recruit Veterans with SCI
10 Veterans with SCI have been recruited.

Recruitment is open and in progress

c) Obtain baseline tissue health assessments *In progress*
Baseline tissue health assessments have been obtained for 10 Veterans with SCI. One new study team member (Katie Schwartz) has been added to assist with tissue health assessments

2) Specific objectives
We will carry out a cross-sectional study of tissue health profiles in a representative cohort of 60 individuals with SCI.

3) Significant Results
Nothing to report

4) Other Achievements
Nothing to report

Task 3: Development and validation of the multi-domain SCIPUD+ structural model:

Activity dates: months 6-20

1) Major activities

a) Develop the SCIPUD+ user interface *In progress*
The user interface is shown below (**Figure 1**). The database currently contains test data for development only.

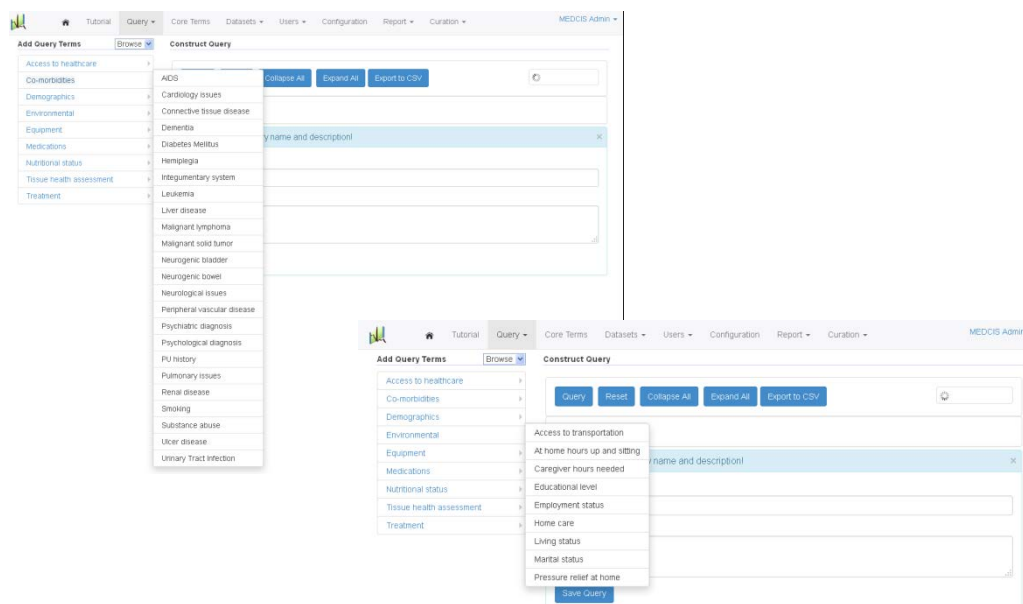


Figure 1: SCIPUD+ user interface development mode

b) Define and test preliminary SCIPUD+ care plan model

Not yet started

2) Specific objectives

In order to develop the SCIPUD+ environmental, social and clinical PU/DTI risk structural model we will consider PU/DTI status as the response variable. Dr. Sun will employ general logistic and multinomial logistic models with linear mixed effects (transformed if necessary) and interaction terms will be fit to the data. Tree-based models such as CART (classification and regression tree) and Random Forest will be also used to examine the relationship of the factors to the PU/DTI status. Model and variable selection will be implemented to define the SCIPUD+ environmental, social and clinical model. Final models will be validated using cross-validation.

3) Significant Results

Nothing to Report

4) Other Achievements

Nothing to Report

Task 4: Observational study of validated SCIPUD+ care plans

Activity dates: months 15-36

1) Major activities

Not yet started

2) Specific objectives

An observational cohort study of personalized SCIPUD+ care plans for PU prevention will be carried out to compare personalized care plans for PU/DTI prevention with standard-of-care. 60 study participants will be recruited from the SCI/D population served by the LSCDVAMC. All participants will receive the detailed skin care education and motivational interviewing package approved by the LSCDVAMC. Participants assigned to the control group will receive standard-of-care assessment and guidance. Participants assigned to the intervention group will receive a personalized SCIPUD+ care plan, focusing on the key outcomes of primary or secondary PU prevention as appropriate. Upon completion of a comprehensive assessment and characterization of individual risk factors, client-specific care plans will be created based on the SCIPUD+ Resource. The Research Nurse will discuss the expectations with the patient, including regular skin assessment and potential behavioral modification. The intervention group will receive ongoing feedback and reminders about their SCIPUD+ personal care plans. The control group will receive standard of care guidance. All study participants will be followed after development of their care plans and invited to complete a short questionnaire on their PU status monthly via a dedicated secure website. PU incidence will be monitored and data applied to refine the SCIPUD+ Resource.

3) Significant Results

Nothing to Report

4) Other Achievements

Nothing to Report

Opportunities for training and professional development

Nothing to Report

Dissemination to communities of interest

We have conducted outreach activities to inform members of our local communities about the study we are conducting. These activities have included outreach to Veterans with spinal cord injury, and professionals involved in the care of individuals with SCI. Dr Bogie also presented a short paper on the background for this study at a major international conference. Outreach activities are listed below:

Oral presentation at World Union of Wound Healing Societies (WUWHS) 2016 Quadrennial Congress, Florence, Italy Sept 25-29, 2016

Harnessing bioinformatics to provide individualized pressure ulcer prevention planning based on clinical practice guideline prioritization.

KM Bogie, GQ Zhang, J Sun, MK Henzel, M Richmond, M Washington, J McDaniel, J Graebert.

Plans for next reporting period to accomplish project goals

Task 1: Creation of the SCIPUD+ environmental, social and clinical domain database:

- Continue development and population of Physio-MIMI based SCIPUD+ Resource database.
- Continue development of NLP protocol for SCIPUDO (SCI PU/DTI Ontology)

Task 2: Creation of the SCIPUD+ tissue health domain database:

- Continue recruitment of Veterans with spinal cord injury of more than 12 months duration
- Continue baseline tissue health assessments
- Continue monthly collection of skin status using short form questionnaire

Task 3: Development and validation of the multi-domain SCIPUD+ structural model:

- Population of Physio-MIMI based SCIPUD+ Resource database with clean and fully deidentified records
- Test preliminary SCIPUD+ care plan model

Task 4: Observational study of validated SCIPUD+ care plans

- Obtain Local IRB and HRPO approvals for observational study of SCIPUD+ care plans

4. IMPACT

Impact on the development of the principal discipline(s) of the project

Nothing to Report

Impact on other disciplines

Nothing to Report

Impact on technology transfer

Nothing to Report

Impact on society beyond science and technology

Nothing to Report

5. CHANGES/PROBLEMS

Changes in approach and reasons for change

Nothing to Report

Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to Report

Changes that had a significant impact on expenditures

Nothing to Report

6. PRODUCTS

Nothing to Report

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Individuals who have worked on the project

Name: Kath Bogie
Project Role: PI
Researcher Identifier 0000-0003-1020-9695(ORCID ID)
Nearest person month worked: 1
Contribution to Project: No change

Name: John McDaniel
Project Role: Co-Investigator
Researcher Identifier N/A
Nearest person month worked: 1
Contribution to Project: Data collection and interpretation

Name: Monique Washington
Project Role: Co-Investigator
Researcher Identifier N/A
Nearest person month worked: 1
Contribution to Project: VINCI data extraction protocol development

Name: Mary K Henzel
Project Role: Co-Investigator
Researcher Identifier N/A
Nearest person month worked: 1
Contribution to Project: SCIPUDO ontology development

Name: Mary Ann Richmond
Project Role: Co-Investigator
Researcher Identifier N/A
Nearest person month worked: 1
Contribution to Project: SCIPUDO ontology development

Name: Jennifer Graebert
Project Role: Study Administrator
Researcher Identifier: N/A
Nearest person month worked: 1
Contribution to Project: Study administration, participant recruitment

Name: Junheng Ma
Project Role: Data Analyst
Researcher Identifier: N/A
Nearest person month worked: 1
Contribution to Project: Data analyst

Name: JC Seton
Project Role: Research Nurse
Researcher Identifier: N/A
Nearest person month worked: 1
Contribution to Project: Study coordinator, Clinical data review

Name: Katie Schwartz
Project Role: Research Assistant
Researcher Identifier: N/A
Nearest person month worked: 2
Contribution to Project: Tissue health assessment of study participants

Changes in active other support of the PI since the last reporting period

Dr Kath Bogie (PI)

Studies ended 10/01/15 -09/30/16

None

New studies 09/30/15 -09/30/16

Started 10/01/15: APTC Garverick Innovation Incentive Program

PI: Majerus S, Cleveland VA Medical Center

Percent effort: 0.6 cal months (*Co-Investigator uncompensated*)

Wireless graft patency monitoring using PDMS-based flexible pulsation sensors

Started 12/01/15: NIH R56: National Institute of Dental and Craniofacial Research

PI: Kaigler D, University of Michigan

Percent effort: 1.2 cal month (Co-Investigator)

Customized craniofacial stem cell therapy for craniofacial bone defects

Other organizations involved as partners

Organization Name: University of Kentucky

Location of Organization: Lexington, Kentucky

Partner's contribution to the project: Collaboration & Facilities

Organization Name: Case Western Reserve University

Location of Organization: Cleveland, Ohio

Partner's contribution to the project: Collaboration & Facilities

8. SPECIAL REPORTING REQUIREMENTS

Not Applicable

9. APPENDICES

Not Applicable